3. Given a transportation problem with the following costs, supply, and demand, find the optimal solution by using the computer:

	To (cost)			
From	1	2	3	Supply
A	\$6	\$7	\$4	100
B	5	3	6	180
C	8	5	7	200
Demand	135	175	170	

4. Consider the following transportation problem:

	To (cost)			
From	1	2	3	Supply
A	\$ 6	\$9	\$*M*	130
B	12	3	5	70
C	4	8	11	100
Demand	80	110	60	

Formulate this problem as a linear programming model and solve it by using the computer.

5. Solve the following linear programming problem:

$$\text{minimize } Z = 3x_{11} + 12x_{12} + 8x_{13} + 10x_{21} + 5x_{22} + 6x_{23} + 6x_{31} + 7x_{32} + 10x_{33}$$

subject to

$$x_{11} + x_{12} + x_{13} = 90$$
$$x_{21} + x_{22} + x_{23} = 30$$
$$x_{31} + x_{32} + x_{33} = 100$$
$$x_{11} + x_{21} + x_{31} \leq 70$$
$$x_{12} + x_{22} + x_{32} \leq 110$$
$$x_{13} + x_{23} + x_{33} \leq 80$$
$$x_{ij} \geq 0$$

6. Consider the following transportation problem:

	To (cost)			
From	1	2	3	Supply
A	\$ 6	\$9	\$ 7	130
B	12	3	5	70
C	4	8	11	100
Demand	80	110	60	

Solve it by using the computer.

Determine the two games each person should get tickets for that will result in the groups' greatest degree of satisfaction. Do you think the participants would think your allocation is fair?

35. World Foods, Inc., imports food products such as meats, cheeses, and pastries to the United States from warehouses at ports in Hamburg, Marseilles, and Liverpool. Ships from these ports deliver the products to Norfolk, New York, and Savannah, where they are stored in company warehouses before being shipped to distribution centers in Dallas, St. Louis, and Chicago. The products are then distributed to specialty food stores and sold through catalogs. The shipping costs ($/1,000 lb.) from the European ports to the U.S. cities and the available supplies (1,000 lb.) at the European ports are provided in the following table:

	U.S. City			
European Port	4. Norfolk	5. New York	6. Savannah	Supply
1. Hamburg	$420	$390	$610	55
2. Marseilles	510	590	470	78
3. Liverpool	450	360	480	37

The transportation costs ($/1,000 lb.) from each U.S. city of the three distribution centers and the demands (1,000 lb.) at the distribution centers are as follows:

	Distribution Center		
Warehouse	7. Dallas	8. St. Louis	9. Chicago
4. Norfolk	$ 75	$ 63	$81
5. New York	125	110	95
6. Savannah	68	82	95
	60	45	50

Determine the optimal shipments between the European ports and the warehouses and the distribution centers to minimize total transportation costs.

36. A sports apparel company has received an order for a college basketball team's national championship T-shirt. The company can purchase the T-shirts from textile factories in Mexico, Puerto Rico, and Haiti. The shirts are shipped from the factories to companies in the United States that silk-screen the shirts before they are shipped to distribution centers. Following are the production and transportation costs ($/shirt) from the T-shirt factories to the silk-screen companies to the distribution centers, plus the supply of T-shirts at the factories and demand for the shirts at the distribution centers:

	Silk-screen Company			
T-shirt Factory	4. Miami	5. Atlanta	6. Houston	Supply (1,000s)
1. Mexico	$4	$6	$3	18
2. Puerto Rico	3	5	5	15
3. Haiti	2	4	4	23

Silk-screen Company	Distribution Center		
	7. New York	8. St. Louis	9. Los Angeles
4. Miami	$5	$7	$9
5. Atlanta	7	6	10
6. Houston	8	6	8
Demand (1,000s)	20	12	20

Determine the optimal shipments to minimize total production and transportation costs for the apparel company.

37. Walsh's Fruit Company contracts with growers in Ohio, Pennsylvania, and New York to purchase grapes. The grapes are processed into juice at the farms and stored in refrigerated vats. Then the juice is shipped to two plants, where it is processed into bottled grape juice and frozen concentrate. The juice and concentrate are then transported to three food warehouses/distribution centers. The transportation costs per ton from the farms to the plants and from the plants to the distributors, and the supply at the farms and demand at the distribution centers are summarized in the following tables:

Farm	Plant		Supply (1,000 tons)
	4. Indiana	5. Georgia	
1. Ohio	$16	21	72
2. Pennsylvania	18	16	105
3. New York	22	25	83

Plant	Distribution Center		
	6. Virginia	7. Kentucky	8. Louisiana
4. Indiana	$23	$15	$29
5. Georgia	20	17	24
Demand (1,000 tons)	90	80	120

a. Determine the optimal shipments from farms to plants to distribution centers to minimize total transportation costs.
b. What would be the effect on the solution if the capacity at each plant were 140,000 tons?

38. A national catalog and Internet retailer has three warehouses and three major distribution centers located around the country. Normally, items are shipped directly from the warehouses to the distribution centers; however, each of the distribution centers can also be used as an intermediate transshipment point. The transportation costs ($/unit) between warehouses and distribution centers, the supply at the warehouses (100 units), and the demand at the distribution centers (100 units) for a specific week are shown in the following table:

Factory	U.S. Distributor		
	7. Texas	8. Virginia	9. Ohio
4. Puerto Rico	$800	$700	$ 900
5. Mexico	600	800	1,100
6. Panama	900	700	1,200

Determine the optimal shipments of laptops that will meet demand at the U.S. distributors at the minimum total cost.

40. The Midlands Field Produce Company contracts with potato farmers in Colorado, Minnesota, North Dakota, and Wisconsin for monthly potato shipments. Midlands picks up the potatoes at the farms and ships mostly by truck (and sometimes by rail) to its sorting and distribution centers in Ohio, Missouri, and Iowa. At these centers the potatoes are cleaned, rejects are discarded, and the potatoes are sorted according to size and quality. They are then shipped to combination plants and distribution centers in Virginia, Pennsylvania, Georgia, and Texas, where the company produces a variety of potato products and distributes bags of potatoes to stores. Exceptions are the Ohio distribution center, which will only accept potatoes from farms in Minnesota, North Dakota, and Wisconsin, and the Texas plant, which won't accept shipments from Ohio because of disagreements over delivery schedules and quality issues. Following are summaries of the shipping costs from the farms to the distribution centers and the processing and shipping costs from the distribution centers to the plants, as well as the available monthly supply at each farm, the processing capacity at the distribution centers, and the final demand at the plants (in bushels):

Farm	Distribution Center ($/bushel)			
	5. Ohio	6. Missouri	7. Iowa	Supply (bushels)
1. Colorado	$—	$1.09	$1.26	1,600
2. Minnesota	0.89	1.32	1.17	1,100
3. North Dakota	0.78	1.22	1.36	1,400
4. Wisconsin	1.19	1.25	1.42	1,900
Processing Capacity (bushels)	1,800	2,200	1,600	

Distribution Center	Plant ($/bushel)			
	8. Virginia	9. Pennsylvania	10. Georgia	11. Texas
5. Ohio	$4.56	$3.98	$4.94	$—
6. Missouri	3.43	5.74	4.65	5.01
7. Iowa	5.39	6.35	5.70	4.87
Demand (bushels)	1,200	900	1,100	1,500

Formulate and solve a linear programming model to determine the optimal monthly shipments from the farms to the distribution centers and from the distribution centers to the plants to minimize total shipping and processing costs.

41. KanTech Corporation is a global distributor of electrical parts and components. Its customers are electronics companies in the United States, including computer manufacturers and audio/visual product manufacturers. The company contracts to purchase components and parts from

manufacturers in Russia, Eastern and Western Europe, and the Mediterranean, and it has them delivered to warehouses in three European ports, Gdansk, Hamburg, and Lisbon. The various components and parts are loaded into containers based on demand from U.S. customers. Each port has a limited fixed number of containers available each month. The containers are then shipped overseas by container ships to the ports of Norfolk, Jacksonville, New Orleans, and Galveston. From these seaports, the containers are typically coupled with trucks and hauled to inland ports in Front Royal (Virginia), Kansas City, and Dallas. There are a fixed number of freight haulers available at each port each month. These inland ports are sometimes called "freight villages," or intermodal junctions, where the containers are collected and transferred from one transport mode to another (i.e., from truck to rail or vice versa). From the inland ports, the containers are transported to KanTech's distribution centers in Tucson, Pittsburgh, Denver, Nashville, and Cleveland. Following are the handling and shipping costs ($/container) between each of the embarkation and destination points along this overseas supply chain and the available containers at each port:

	U.S. Port				
European Port	4. Norfolk	5. Jacksonville	6. New Orleans	7. Galveston	Available Containers
1. Gdansk	$1,725	$1,800	$2,345	$2,700	125
2. Hamburg	1,825	1,750	1,945	2,320	210
3. Lisbon	2,060	2,175	2,050	2,475	160

	Inland Port			
U.S. Port	8. Dallas	9. Kansas City	10. Front Royal	Intermodal Capacity (containers)
4. Norfolk	$825	$545	$ 320	85
5. Jacksonville	750	675	450	110
6. New Orleans	325	605	690	100
7. Galveston	270	510	1,050	130
Intermodal Capacity (containers)	170	240	140	

	Distibution Center				
Inland Port	11. Tucson	12. Denver	13. Pittsburgh	14. Nashville	15. Cleveland
8. Dallas	$ 450	$830	$ 565	$420	$960
9. Kansas City	880	520	450	380	660
10. Front Royal	1,350	390	1,200	450	310
Demand	85	60	105	50	120

Formulate and solve a linear programming model to determine the optimal shipments from each point of embarkation to each destination along this supply chain that will result in the minimum total shipping cost.

42. In Problem 41, KanTech Corporation is just as concerned that its U.S. distributors receive shipments in the minimum amount of time as they are about minimizing their shipping costs. Suppose that each U.S. distributor receives one major container shipment each month. Following are summaries of the shipping times (in days) between each of the embarkation and destination points

44. A plant has four operators to be assigned to four machines. The time (minutes) required by each worker to produce a product on each machine is shown in the following table:

	Machine (min.)			
Operator	A	B	C	D
1	10	12	9	11
2	5	10	7	8
3	12	14	13	11
4	8	15	11	9

Determine the optimal assignment and compute total minimum time.

45. A shop has four machinists to be assigned to four machines. The hourly cost of having each machine operated by each machinist is as follows:

	Machine (cost/hr.)			
Machinist	A	B	C	D
1	$12	$11	$ 8	$14
2	10	9	10	8
3	14	8	7	11
4	6	8	10	9

However, because he does not have enough experience, machinist 3 cannot operate machine B.

a. Determine the optimal assignment and compute total minimum cost.
b. Formulate this problem as a general linear programming model.

46. The Omega pharmaceutical firm has five salespersons, whom the firm wants to assign to five sales regions. Given their various previous contacts, the salespersons are able to cover the regions in different amounts of time. The amount of time (days) required by each salesperson to cover each city is shown in the following table:

	Region (days)				
Salesperson	A	B	C	D	E
1	17	10	15	16	20
2	12	9	16	9	14
3	11	16	14	15	12
4	14	10	10	18	17
5	13	12	9	15	11

Which salesperson should be assigned to each region to minimize total time? Identify the optimal assignments and compute total minimum time.